TRANSLATION OF ARTICLE 34 AMENDMENTS

New Description Pages

Insulated conductor pins are inserted into these holes that have a size of a few hundred µm and these pins are firmly connected to a conductive layer on the front. The serial connection of the arrays is achieved by installing conductor bridges, after which the arrays are electrically separated from each other at the end of the procedure. The disconnection points are encapsulated with insulating and concurrently adhesive materials.

In another embodiment, which is likewise described in German preliminary published application DE 100 52 914 A1, the approach taken during the production of the semiconductor component system is that different semiconductor component types (n-material and p-material) are applied alternately onto defined surface areas. Thus, areas with positive or negative electrodes are alternately formed on one side of a system, and these electrodes can be connected in series by an integrated connection. For this purpose, the electrode layers are interrupted alternately on the top and on the bottom. The placement of different semiconductor component types in order to create a surface with different electrodes, however, is an expensive method.

Moreover, U.S. Pat. No. 4,407,320 discloses a method for the production of solar cells in which spherical semiconductor elements are incorporated into an insulating layer. The spheres have a semiconductor of n-type material on one side whereas they have a semiconductor of p-type material on the other side. In each case, a conductive layer is applied onto both sides of the insulating layer in order to connect the spheres to each other. Furthermore, conductive separation lines are made consisting of spheres, a paste or, for example, a wire. In order to produce a serial connection, alternating cuts are made into the conductive layers on both sides of the conductive separation line.

It is also a known procedure to configure independent spherical semiconductor elements that constitute complete semiconductors, including the requisite electrodes. For example, European patent application EP 0 940 860 A1 describes using a spherical core to make a spherical semiconductor element by means of masking, etching steps and the application of various material layers. Such semiconductor elements can be used as solar cells if the p-n junction is selected in such a way that it can convert incident light into energy. If the p-n

junction is configured in such a way that it can convert an applied voltage into light, then the semiconductor element can be employed as a light-emitting element.

Moreover, U.S. Pat. No. 5,578,503 discloses a method for the rapid production of chalcopyrite semiconductor layers on a substrate in which individual layers of the elements copper, indium or gallium and sulfur or selenium are applied onto a substrate in elemental form or as a binary interelemental compound. The substrate with the layer structure is then quickly heated up and kept at a temperature of ≥ 350°C [≥ 662°F] for between 10 seconds and one hour.

The objective of the invention is to provide a method for the production of serial connections of solar cells having integrated semiconductor elements that can be carried out with just a few simple process steps.

Moreover, it is the objective of the invention to provide a serial connection of solar cells having integrated semiconductor elements that is produced with just a few process steps that are simple to carry out.

Furthermore, it is the objective of the invention to provide a photovoltaic module with serially connected solar cells.

According to the invention, this objective is achieved by the features of claims 1, 18 and 43. Advantageous refinements of the invention can be gleaned from the subordinate claims.

In the method according to the invention for the production of a serial connection of solar cells having integrated semiconductor elements, one or more conductive elements and spherical or grain-shaped semiconductor elements are incorporated into an insulating support layer according to a pattern, whereby the elements protrude from the surface of the support layer on at least one side of the support layer, and the pattern calls for at least one continuous separation line having the width B consisting of conductive elements. The areas next to a separation line or between several lines are fitted with semiconductor elements.

In an especially preferred embodiment of the invention, the pattern in the support layer provides that a distance exists between a separation line and an area that is fitted with

semiconductor elements, so that, next to a separation line, a thin strip is formed into which separation cuts can be made without the conductive elements or the semiconductor elements being touched and likewise being cut. It is also possible not to have any distance so that the separation cuts are made in such a way that, as a result, parts of the conductive elements and/or of the semiconductor elements are cut off.

The elements incorporated into the support layer can be, for example, elements made of solid material or ...

New Claims

1. A method for the production of a serial connection of solar cells having integrated semiconductor elements, characterized by the following features:

- incorporation of one or more conductive elements (20) into an insulating support layer (10) according to a pattern, whereby the conductive elements (20) protrude from the surface of the support layer on at least one side of the support layer, and the pattern calls for at least one separation line (21) having a width B and consisting of one or more conductive elements (20);
- incorporation of several spherical or grain-shaped semiconductor elements (30) into the insulating support layer (10) according to a pattern, whereby the semiconductor elements (30) consist of substrate cores that are coated at least with one conductive back contact layer made of molybdenum and with one semiconductor layer made of a I-III-VI compound semiconductor arranged above it, the semiconductor elements (30) protrude from the surface of the support layer on at least one side of the support layer, and the pattern provides that the areas next to a separation line (21) or between several separation lines (21) consisting of conductive elements (20) are fitted with semiconductor elements (30);
- removal of parts of the semiconductor elements (30) on one side of the support layer (10) until the back contact layer of the semiconductor elements (30) is exposed;
- application of a conductive back contact layer (50) onto the side of the support layer (10) on which parts of the semiconductor elements (30) have been removed;
- application of a conductive front contact layer (40) onto the side of the support layer (10) on which no semiconductor elements have been removed, whereby before and/or after the deposition of the front contact layer (40) and/or of the back contact layer (50), a buffer layer made of CdS and/or a layer made of intrinsic zinc oxide are deposited, or a buffer layer made of CdS and/or a layer made of intrinsic zinc oxide had already been deposited onto the spherical or grain-shaped semiconductor elements (30) employed;
- making of two separation cuts (60; 61) along a separation line (21) consisting of conductive elements (20), whereby a first separation cut (60) is made in the front contact layer (40) and a second separation cut (61) is made in the back

contact layer, the separation cuts are on different sides of the appertaining separation line (21), and the separation cuts (60; 61) penetrate the back contact layer (50) all the way to the support layer (10).

2. The method according to claim 1, characterized in that the spherical or grain-shaped semiconductor elements (30) have a layer made of transparent conductive oxide (TCO).

3. The method according to one or both of the preceding claims 1 and 2, characterized in that, in addition to removing parts of the semiconductor elements (30), parts of the conductive elements (20) are also removed.

4. The method according to one or more of the preceding claims, characterized in that, in addition to the removal of parts of the semiconductor elements (30), part of the support layer (10) is removed.

5. The method according to one or more of the preceding claims, characterized in that the conductive elements (20) and/or the semiconductor elements (30) are applied onto the support layer (10) by means of scattering, dusting and/or printing, after which they are incorporated into the support layer.

6. The method according to one or more of the preceding claims, characterized in that several conductive elements (20) in the form of spherical or grain-shaped particles, in the form of strips or in the form of a paste are incorporated into the support layer (10).

7. The method according to one or more of the preceding claims, characterized in that the conductive elements (20) and/or the semiconductor elements (30) are arranged into a pattern using an auxiliary means and the elements (20; 30) are placed onto and/or into the support layer using the auxiliary means.

8. The method according to one or more of the preceding claims, characterized in that the support layer (10) is a matrix with recesses into which the elements (20; 30) are incorporated.

9. The method according to one or more of the preceding claims, characterized in that elements (20; 30) are incorporated into the support layer (10) by means of a heating and/or pressing procedure.

10. The method according to one or more of the preceding claims, characterized in that a separation line (21) consisting of conductive elements (20) extends between two edges of the support layer (10) that are opposite from each other.

11. The method according to one or more of the preceding claims, characterized in that the removal of the elements (20; 30) and/or of the support layer (10) is done by means of grinding, polishing, etching, thermal energy input and/or by photolithographic processes.

12. The method according to one or more of the preceding claims, characterized in that the back contact layer (50) and the front contact layer (40) are deposited by PVD methods, CVD methods or other methods that have been adapted to the type of the layer in question.

13. The method according to one or more of the preceding claims, characterized in that the separation cuts (60; 61) are made using methods such as cutting, scoring, etching, thermal energy input or by photolithographic processes.

14. The method according to one or more of the preceding claims, characterized in that the width of a separation line (21) is in the order of magnitude of B = 10 μm to 3 mm, especially between 10 μm and 500 μm.

15. The method according to one or more of the preceding claims, characterized in that the distance between two separation lines (21) is in the order of magnitude of 1 mm to 3 cm, especially between 3 mm and 5 mm.

16. A serial connection of solar cells having integrated semiconductor elements, characterized in that the serial connection has at least the following features:

- an insulating support layer (10) into which one or more conductive elements (20) are incorporated according to a pattern, whereby the conductive elements (20) protrude from the surface of the support layer on at least one side of the support layer, and the pattern calls for at least one separation line (21) having a width B and consisting of one or more conductive elements (20);
- several spherical or grain-shaped semiconductor elements (30) in the insulating support layer (10), whereby the semiconductor elements (30) consist of a substrate core that is coated at least with one conductive back contact layer made of molybdenum and with one semiconductor layer made of a I-III-VI compound semiconductor, and the semiconductor elements (30) protrude from the surface of the support layer on at least one side of the support layer and form a pattern in which the areas next to a separation line (21) or between several separation lines (21) are fitted with semiconductor elements (30);
- a conductive front contact layer (40) on one side of the support layer (10) on which the elements (20; 30) protrude from the layer;
- a conductive back contact layer (50) on the side of the support layer that is opposite from the front contact layer (40);
- a buffer layer made of CdS and/or a layer made of intrinsic zinc oxide, or a buffer layer made of CdS and/or a layer made of intrinsic zinc oxide already on the spherical or grain-shaped semiconductor elements (30) employed;
- in each case, two separation cuts (60; 61) along a row of conductor elements (20), whereby a first separation cut (60) is made in the front contact layer (40) and a second separation cut (61) is made in the back contact layer, the separation cuts are on different sides of the appertaining row of conductive elements (20), and the separation cuts (60; 61) penetrate the back contact layer (50) all the way to the support layer (10); and
- on the side of the support layer (10) on which the back contact layer (50) of the solar cell is arranged, at least one of the semiconductor elements (30) has a surface via which a direct contact is established between the back contact layer (50) of the solar cell and the back contact layer of the semiconductor element (30).

17. A serial connection according to claim 16, characterized in that the support layer (10) consists of a thermoplastic material.

18. The serial connection according to one or both of claims 16 and 17, characterized in that the support layer (10) consists of a polymer from the group comprising epoxides, polyurethanes, polyacrylics, polycarbonates, polyesters and/or polyimides.

19. The serial connection according to one or more of claims 16 to 18, characterized in that a conductive element (20) is formed by a paste or by a strip.

20. The serial connection according to one or more of claims 16 to 19, characterized in that a conductive element (20) is formed by a spherical or grain-shaped particle.

21. The serial connection according to claim 20, characterized in that a conductive element (20) is made of a conductive material in the form of a solid material, or a conductive element (20) consists of a substrate core that is coated with a conductive material.

22. The serial connection according to claim 21, characterized in that a conductive element (20) is made of copper in the form of a solid material or of a substrate core that is coated with copper.

23. The serial connection according to one or more of claims 16 to 22, characterized in that the semiconductor elements (30) have a layer made of transparent conductive oxide (TCO).

24. The serial connection according to one or more of claims 16 to 23, characterized in that the separation line (21) consisting of conductive elements (20) is essentially straight and it extends between two edges of the support layer (10) that are opposite from each other.

25. The serial connection according to one or more of claims 16 to 24, characterized in that the width of a separation line (21) is in the order of magnitude of B = 10 μm to 3 mm, especially between 10 μm and 500 μm.

26. The serial connection according to one or more of claims 16 to 25, characterized in that the distance between two separation lines (21) is in the order of magnitude of 1 mm to 3 cm, especially between 3 mm and 5 mm.

27. The serial connection according to one or more of claims 16 to 26, characterized in that the front contact layer (40) is made of a conductive material.

28. The serial connection according to claim 27, characterized in that the front contact layer (40) is made of a transparent conductive oxide (TCO).

29. The serial connection according to one or more of claims 16 to 28, characterized in that the back contact layer (50) is made of a metal, of a transparent conductive oxide (TCO) or of a conductive polymer.

30. The serial connection according to claim 29, characterized in that the back contact layer (50) consists of a polymer from the group comprising the epoxy resins, polyurethanes and/or polyimides having conductive particles of a group comprising carbon, indium, nickel, silver, molybdenum, iron, nickel chromium, aluminum and/or the corresponding alloys or oxides.

31. The serial connection according to claim 30, characterized in that the back contact layer (50) consists of an intrinsic conductive polymer.

32. The serial connection according to one or more of claims 16 to 31, characterized in that the separation cuts (60; 61) are filled up with an insulating material.

33. The serial connection according to one or more of claims 16 to 32, characterized in that the serial connection is strip-like.

34. The serial connection according to one or more of claims 16 to 33, characterized in that the width of the serial connection is in the order of magnitude of 5 cm to 30 cm, especially approximately 10 cm.

35. The serial connection according to one or more of claims 16 to 34, characterized in that serial connection is joined to another serial connection in such a way that the back contact layer (50) is in contact with a front contact layer of the other serial connection.

36. The serial connection according to claim 35, characterized in that the serial connection is joined to at least another serial connection in a shingle-like configuration, whereby the back contact layer (50) lies on a front contact layer or else the front contact layer (40) lies on a back contact layer of the other serial connection.

37. The serial connection according to one or both of claims 35 to 36, characterized in that the back contact layer (50) is joined by means of a conductive adhesive to a front contact layer of the other serial connection.

38. A photovoltaic module, characterized in that it comprises a serial connection according to one or more of claims 16 to 37.